ENGINEERING CASE LIBRARY

ECL 267

MECHANICAL POWER PRESS SAFETY STUDY

This case is a study of operator protection and guarding on a mechanical power press. An analysis of modifications made to the press with the evolution of safety standards is given. A study of an engineering investigation for a product liability suit is presented.

T. Willis, Ph.D., P. E.
Willis, Kaplan & Associates, Inc.
3335 N. Arlington Heights Rd.
Arlington Heights, IL 60004

This engineering case was prepared in fulfillment of P. O. 85-35129 under the sponsorship of the Division of Training and Manpower Development, National Institute for Occupational Safety and Health.

(Names, but not facts, have been changed.)

A. MECHANICAL POWER PRESS SAFETY STUDY - ACME PRESS COMPANY 30T PRESS

1. ACQUIRING THE NEW PRESS - 1945

Jim Smith was Chief Engineer for Acme Tool Company. In May 1945, they had won a major contract with an electrical hardware manufacturer (Acme Electric) to manufacture housings for several models of electrical switch boxes. As this was a sizeable increase in production for Acme Tool, Smith determined that three new presses would be necessary. Acme Tool was a modest size contract machine shop having more than 20 years experience at this point. They already owned eight presses, three manufactured by Acme Press Company, and several other pieces of equipment such as press brakes, shears, etc. Exhibits 1 and 2 illustrate basic aspects of a mechanical power press.

Chief Engineer Smith talked with several press manufacturers, including Acme Press Company whom he knew from previous dealings. Acme Press Company (not related in any way to Acme Tool Company) had given Smith good technical field service in the past, having first class service technicians always available in case of need and they had good delivery schedules on parts. Their equipment appeared to him to be well designed and had always given him relatively trouble free service. Finally, they could offer good prices by virtue of their large size and vast experience in their field.

The machines were to be purchased new by Acme Tool Company. The subject machine in particular was acquired for the express purpose of producing backing plates for electrical switch boxes. These plates are produced from blanks which are low carbon steel sheet, 6 inch x 4 1/8 inch x 1/16 thick. Details of the blank and the finished part are shown in Exhibit 3. The press operation involves punching of four screw holes, one at each corner, and forming the recessed center portion of the backing plate. A most important factor in the purchase decision was the extensive contract acquired by Acme Tool Company. The economics allowed that the presses be fully purchased within the confines of this contract. For this reason, the machines were considered by Jim Smith at Acme Tool Company to be dedicated to this project. These presses were purchased to do only one job, and this was discussed extensively with several candidate press manufacturers.

Acme Press Company was eventually selected as

supplier. Jim Smith at Acme Tool Company decided that their 30 ton machine was his best buy for the job, in terms of production ability, reliability, cost, and manufacturer support.

2. DESCRIPTION OF THE PRESS SELECTED

The machine selected was designed and built in 1945. It was a 30 Ton Open Back Inclinable (OBI) press, of the full-revolution clutch design, manufactured by Acme Press Company. The full revolution design was selected by Jim Smith for its simplicity of design, reliability and price.

The clutch was of the rolling key type, and had a single engaging point per revolution. The clutch was engaged through a mechanical linkage mechanism activated by the operator by a foot treadle. The clutch and its actuating rolling key system are shown schematically in Exhibit 4. The stroke of the press is 5 inches, and the flywheel shaft speed is 60 rpm. Acme Press Company did not provide the machine with a non-repeat mechanism at the time of manufacture, since it was not specified by the purchaser (Acme Tool Company). Furthermore this mechanism was not required by the American Standards Association code B11.1 for this type if the press were used with particular operator protection methods such as sweep guards and selected barrier guards. Both Jim Smith of Acme Tool and the sales engineers from Acme Press Company agreed that the extra cost was not warranted for this additional safety feature.

3. MACHINE FEEDING METHOD

It was decided that the press would be both hand fed and hand cleared, and the dies were designed accordingly. Smith considered this a good method and relatively inexpensive, since auxiliary mechanisms involved in an automatic feeder and extractor would be complex and could involve reliability problems. It would require outside help to design and fabricate, and the overall cost would be high, both initial cost and maintenance costs.

The operator was to receive blanks in boxes, stacked to the right on a table near his/her machine. These would then be placed singly into the lower die where locator pins would guarantee accurate placement. The press

would be tripped by the foot treadle. After completion of the stroke, the operator would reach in and remove the finished part, placing it in a basket located to his/her left. Another cycle could then be initiated.

4. OPERATOR PROTECTION

In 1945, Acme Tool Company already was operating eight presses, and had experience with several systems of operator protection. Two presses had two-hand tripping mechanisms, two others had sweep guards. The sweep guard is a metal bar which sweeps across in front of the die area as the press descends. This pushes the operators hands away from the hazard zone as the dies close. The movement of the sweep guard is synchronized with the movement of the ram, and the sweep mechanism is connected to the ram. Single or double sweep arms may be used. The operator protection on the remaining Acme Tool Company presses was achieved by manual feeding with special hand tools (grippers, tongs etc.).

In addition to these three systems, Jim Smith felt that the overall quality of operators available in the their work pool was high, that their workers had a good safety attitude, and that the training and instruction on press operations at Acme were good. Very experienced die set-up men and operators were always available to properly instruct new employees on safe operating practices.

In this context, Smith selected the single sweep guard as a safety device for this operation. He felt that this would account for any additional safety margin required over and above the natural safety consciousness of the operators, and would allow faster production rates than using tongs, etc. Two hand tripping was rejected because of several reasons:

- Potential reliability problems
- Potential to wedge or jam one button, so that the press became a one hand trip system
- More expensive
- The American Standards Association code required that the press would also need a non-repeat mechanism if these were used.

Exhibits 5 through 11 show several methods or devices which can be used for operator protection at a mechanical power press.

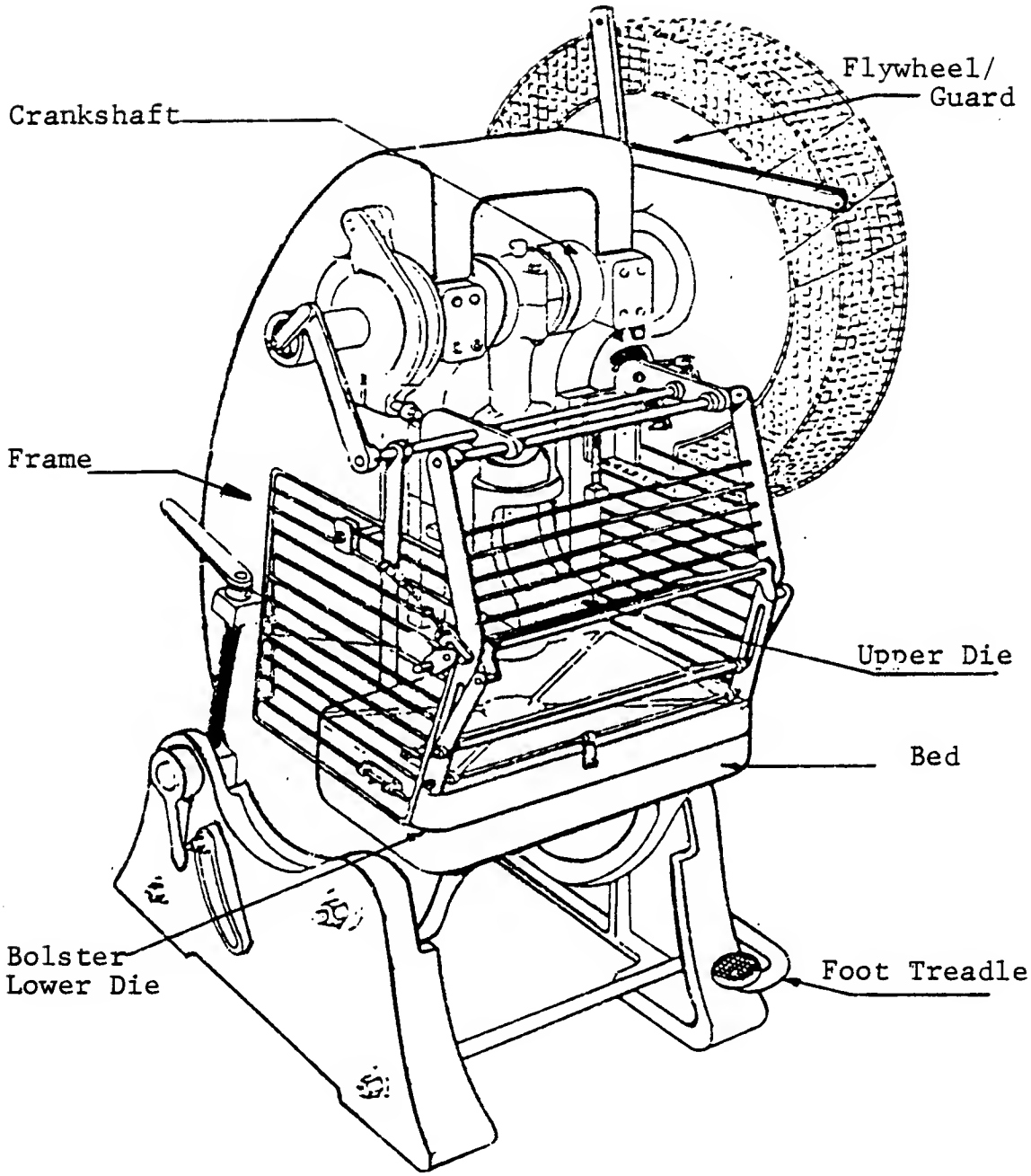
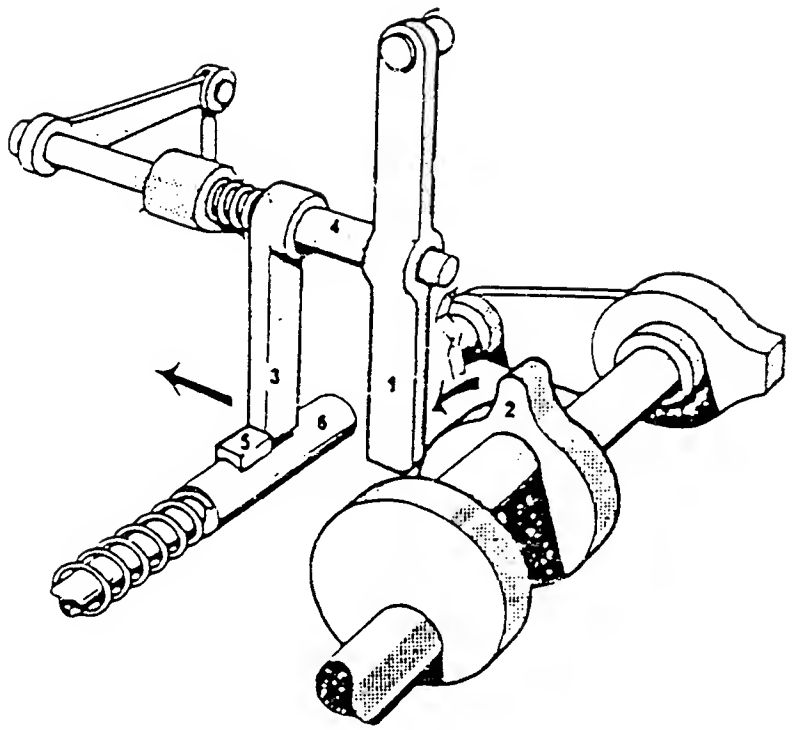


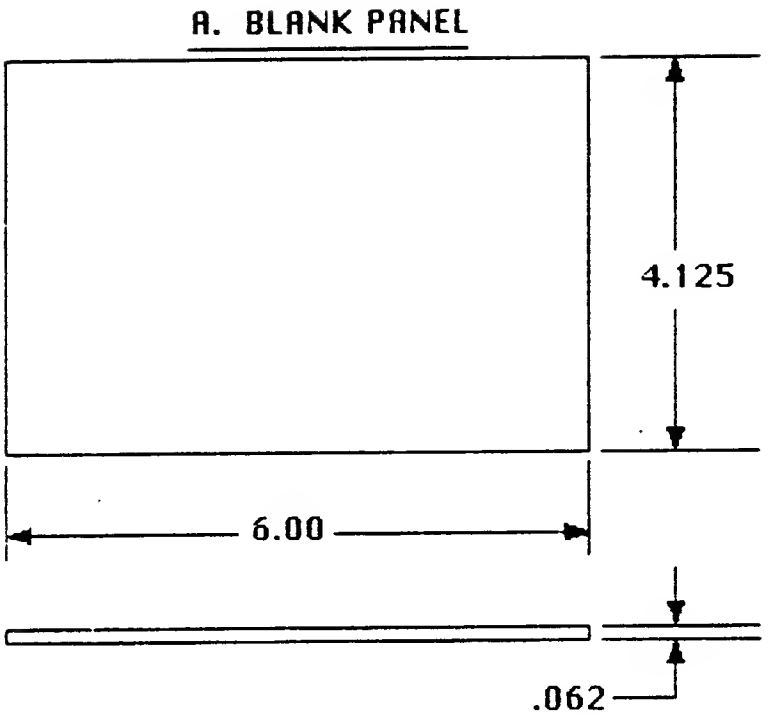
Exhibit 1. Basic Elements of Mechanical Power Press



Single-stroke device

A single-stroke device is provided for the purpose of disengaging the clutch withdrawal device (e.g. extractor) from the influence of the operating control, so that it will disengage the clutch before a second stroke can occur. In the illustration, a lever 1 is struck by lug 2 on one of the crank webs at an appropriate point in the crankshaft rotation. The sleeve 4 is forced backwards, and as a consequence lever 3 is pushed away from lug 5 so that the compression spring pushes the extractor shaft and extractor 6 to the clutch disengaging position. Thus, if the pedal has been kept depressed the means of holding the extractor in the engaged position is removed. Single-stroke devices can be put out of action (by means which are not shown in this illustration) when continuous operation of a press is required

Exhibit 2. Single Stroke Device



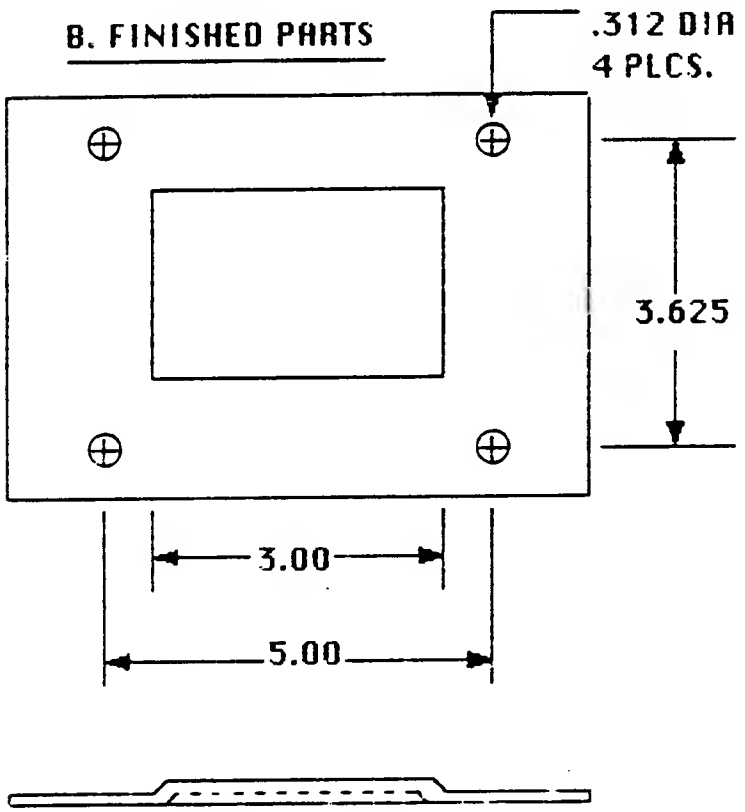


EXHIBIT 3

BLANK PANEL AND FINISHED PARTS

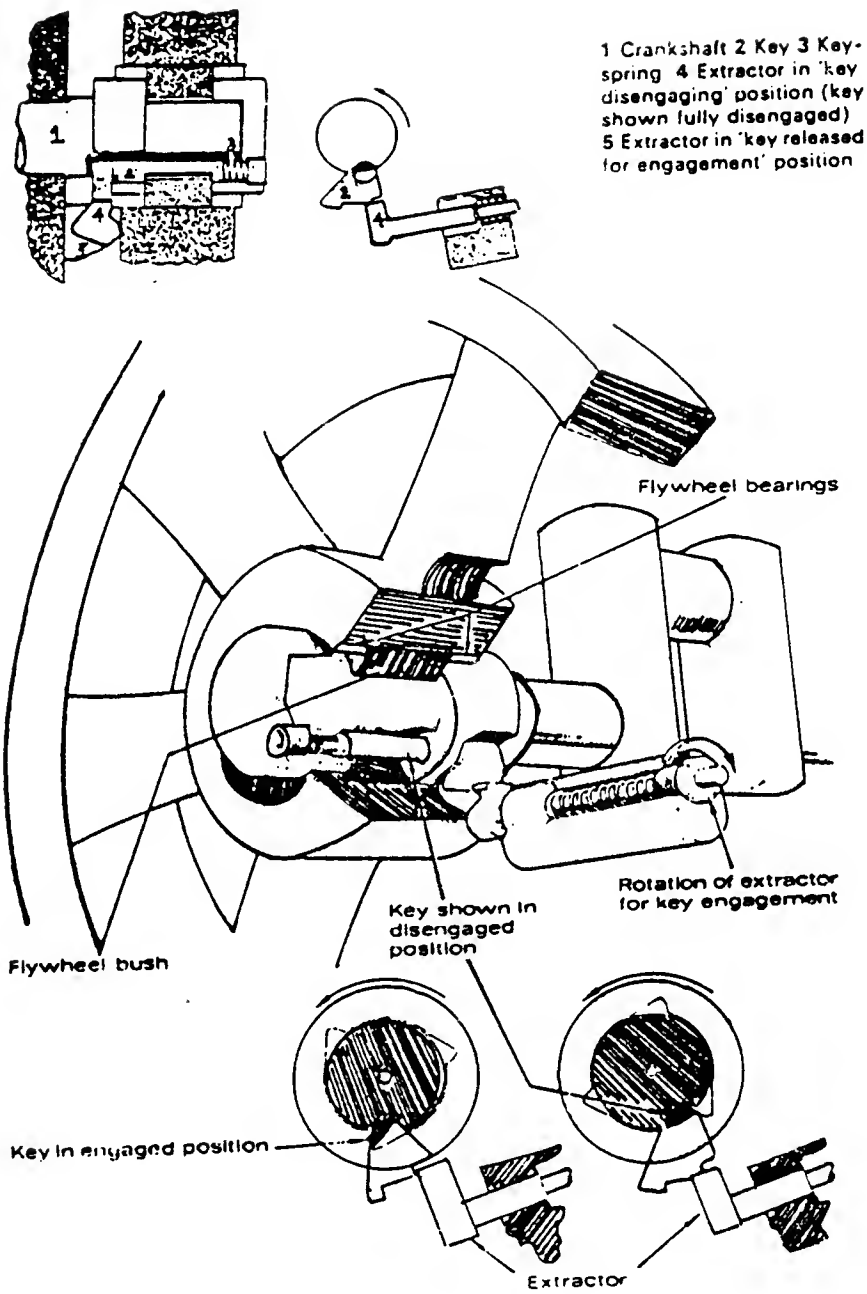


Exhibit 4. Schematic of Rolling Key Clutch on Selected Press

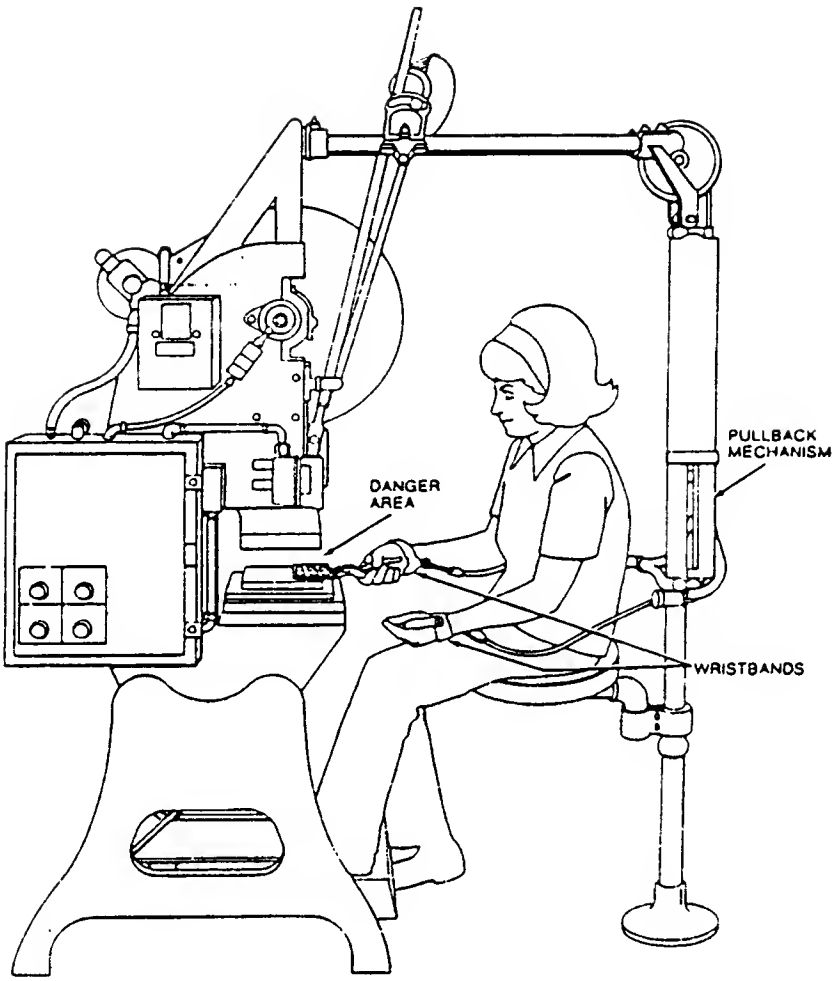


Exhibit 5. Pull-back Device on a Power Press

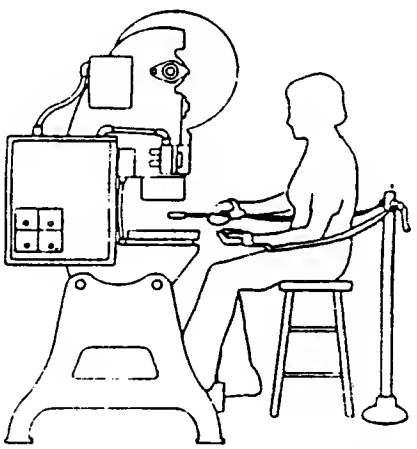


Exhibit 6. Restraint Device on a Power Press

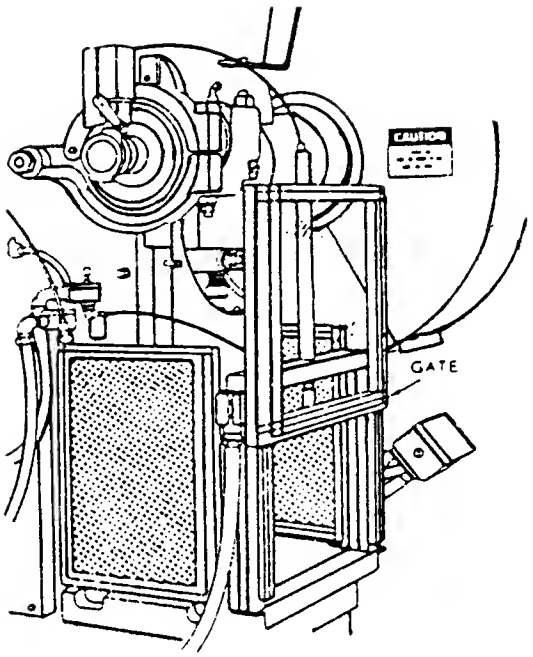


Exhibit 7. Power Press with Gate

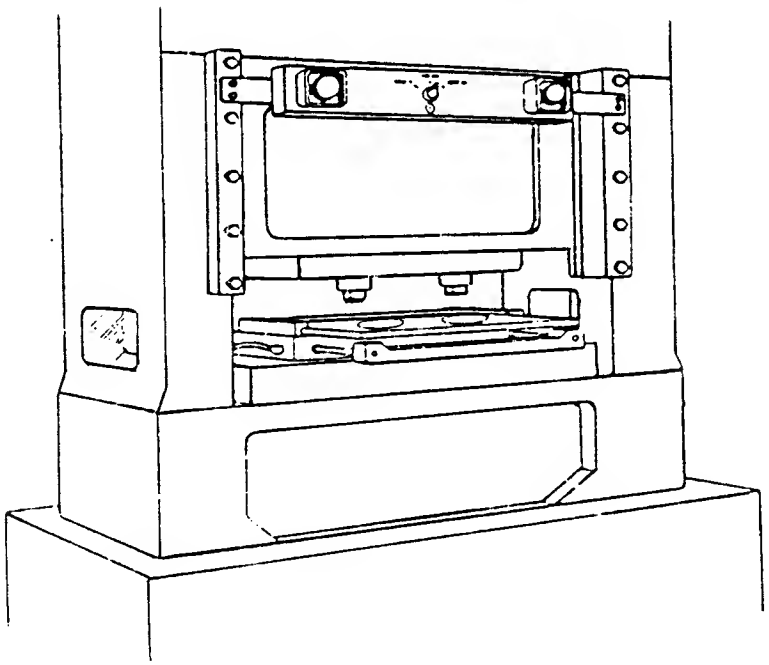


Exhibit 8. Two Hand Trip Buttons on Power Press

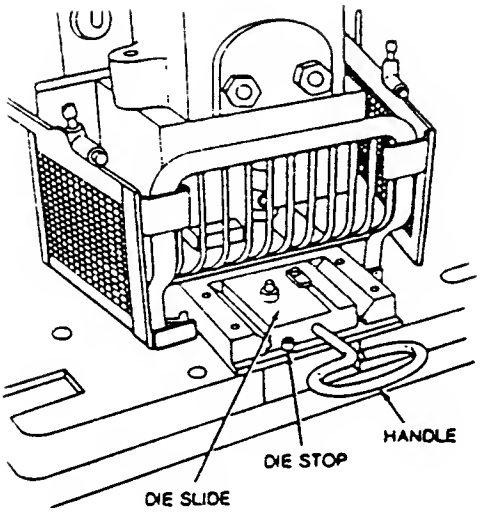


Exhibit 9. Power Press with Sliding Die

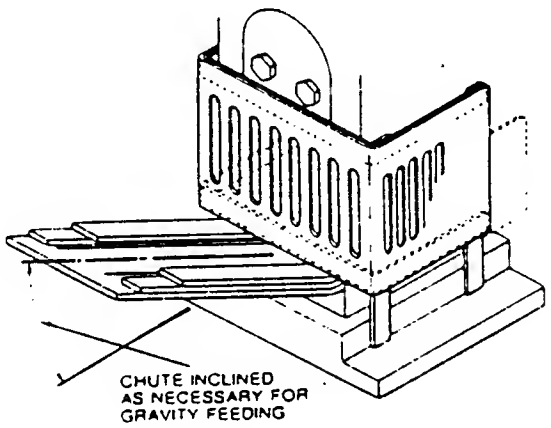


Exhibit 10. Power Press with Chute Feed

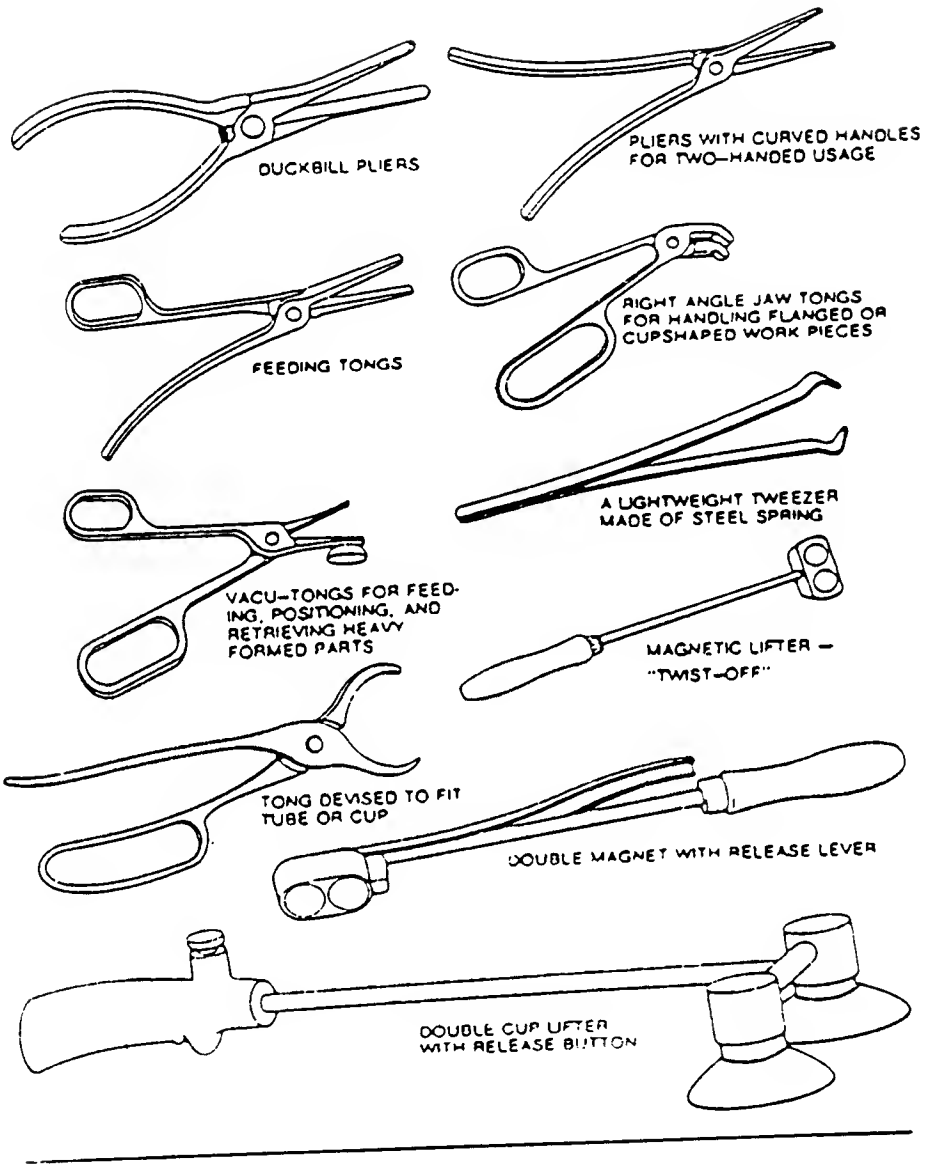


Exhibit 11. Holding Tools

C. MODIFICATIONS TO THE MACHINE

1. MACHINE HISTORY

The Acme 30T Press, manufactured in 1945, was initially purchased and used by Acme Tool Company, for a specific job purpose. The equipment was sold in 1964, having been used for approximately 18 years for its original job (or others very similar). The new owners made no significant modifications. The principal safety device in use on the machine remained the sweep guard.

In 1972, the machine was sold again, this time to a machine rebuilding company (Acme Rebuilding Company), whose intention was to rebuild the machine, convert it to an air activated full revolution clutch, replacing the foot treadle and mechanical linkages with a two-hand trip system, and adding an anti-repeat feature. The intention was to bring the machine into compliance with OSHA regulations (OSHA 2206, 29 CFR 1910 - Section 1910.217 - Mechanical Power Presses). The press was sold to Acme Products in January, 1973, and was in continuous service at that plant through 1983, with no further modifications to the press.

2. SAFETY MODIFICATIONS - 1972

Acme Rebuilding made two major modifications to the press which directly affected the safety of operation. These were:

(a) Convert the mechanical foot treadle actuation to a pneumatic hand actuated system

(b) Introduce an anti-repeat mechanism into the control circuit.

PNEUMATIC ACTUATION

The linkage which released the rolling key in the clutch to allow engagement of the crank shaft was replaced by a pneumatic actuator (piston and linkages) so that the operator could just press two hand buttons and the press cycle would be initiated.

The two buttons were electrical controls, which activated a single solenoid valve when they were both pressed at the same time. However, these were not of

anti-tie down design. The spool in the solenoid valve was moved by the actuation of the electrical solenoid so that compressed air from the shop air supply (80 psi) was admitted through the valve and into the pneumatic actuator. In turn, this actuator rotated the extractor at the clutch, allowing engagement of the rolling key and cycling of the press. The disengagement cam (single stroke mechanism) remained as before.

The purpose of this modification was to require two-hand tripping, since this was considered by Acme Rebuilding as a safer technique than the original sweep device. They considered that the sweep device itself could cause injury. Furthermore, the foot treadle allowed both hands of the operator to be free during the press stroke, and in the event of a problem with the sweep device, protection was no longer available.

ANTI-REPEAT MECHANISM

OSHA 1910.217 (b) (6) (ii) states:

"Two-hand trip systems on full revolution clutch machines shall incorporate an anti-repeat feature."

Acme Rebuilding Company introduced this by means of a limit switch mounted on the machine frame in close proximity to the crankshaft. A switch actuator cam was mounted on the crankshaft. Closing of the limit switch caused electrical power to activate the solenoid air valve. The limit switch actuator cam was adjusted so that the switch was opened as the press began to cycle, and remained open until the press returned to the top of its stroke and was stopped with the brake engaged. In order to restart another cycle, it became necessary to close the limit switch, which was accomplished through the two-hand trip buttons at the operator station.

For continuous operation, the main control had a key switch, which permits selection of single stroke or continuous run modes. In continuous run, the limit switch system is electrically by-passed, so when the operator initiates the run, the machine will perform in continuous operation. Since the selector switch is of the key type, similar to the ignition switch in an automobile, the supervisor can retain control of the key and only switch to continuous run mode when the machine is properly guarded for this. This protects against operators who might try to run the machine continuously and try to feed and extract

parts rapidly for production purposes.

Exhibits 12, 13, and 14 show the press as modified, including detail of the new actuation linkage.

D. THE JONES ACCIDENT

Tom Jones was an employee of Acme Products. He joined the company in 1967, as a set-up man and mechanic. His principal duties were to install and adjust dies in the presses, perform routine press maintenance lubrication, replacement of worn parts etc., and to assist operators in trouble shooting problems. On September 21st, 1981, he was called to the Acme Press by the operator, Mrs. Brown.

The subject press was being used to form metal trays from a flat rectanglar blank. Ultimately the product was for industrial storage trays. For this operation, the machine mode selector was in single stroke run mode, and the machine power was on - electric motor and flywheel running. Because of the product geometry, the press stroke was set at 4 1/2 inches, and the machine was being hand fed. The blanks measured 20 in. x 14 in. and were of 0.032 inch steel. The blanks were already slotted. They were folded to form a 12 in. x 6 in. x 4 in. tray by the press. The trays were then taken to another work-station for tack welding.

Blanks were hand fed into the machine, and were retrieved by hand after the forming operation. The lower die was fabricated from several subcomponent parts. Two screws were located within the base of the main section, whose purpose was to fasten the subcomponents of the die to the main body of the die. These screws periodically worked loose. Over a time span of about an hour, as they backed out of their position, they began to intrude into the die cavity where the sheet metal product was located. The screw head caused a small unwanted imprint in the 12 x 6 x 4 inch sheet metal tray that was being formed in the press. The operator asked Jones to investigate the reason for the unwanted imprint. He recognized the problem and began to screw the two screws down tight.

Jones successfully screwed down the left side screw, and he then moved to his right to work on the remaining one. As he moved his hand forward toward the screw, the press cycled once, amputating three fingers on his right hand.

Shortly after the accident, and before the press was placed into normal operation, the plant safety manager and the maintenance superintendent examined the machine. They found that it operated correctly, that it did not repeat strokes continuously, and that the machine appeared to be behaving normally. Neither of the control buttons were tied down in any way which would defeat the two hand trip concept.

Acme Products, as Mr. Jones employer, were cited and fined by OSHA for violations relating to Title 29, Chapter XVII, Section 1910.217 (b) (6) (i).

"Two-hand trip - A two-hand trip shall have the individual operator's hand controls protected against unintentional operation and have the individual operator's hand controls arranged by design and construction and/or separation to require the use of both hands to trip the press and use a control arrangement requiring concurrent operation of the individual operator's hand controls".

E. JONES vs ACME PRESS COMPANY

Subsequent to his accident, Mr. Jones consulted a lawyer specializing in personal injury cases. The lawyer advised him that as an employee, he was covered under Workmen's Compensation Insurance for his injury, and that insurance was paid for by his employer Acme Products. He was barred from any further recovery from his employer, and advised that the law allows recovery from the machine manufacturer or machine rebuilder if certain legal criteria are met. Among others, three of these criteria are that the machine was defective in its design at the time it left the control of the manufacturer or rebuilder, that the machine is essentially unchanged since that time, and that the defect was a proximate cause of his accident. The attorney informed Jones that the legal basis would be one of strict liability, meaning among other things that any contribution to the accident by Jones himself could not be taken into account in the lawsuit, and only the design of the machine could be considered.

He advised Mr. Jones that in his judgement it would be worthwhile to undertake an engineering investigation into the matter and that a mechanical engineering design consultant should be retained for this purpose. Mr. Green, a registered professional engineer, who was a staff engineer for the firm of Acme Engineering Consultants, was retained.

Green was provided with a description of the accident by the lawyer, and was told that the equipment was an Acme Press Company 30T machine, probably manufactured prior to 1960. At this point in time, since a lawsuit had not been filed, the discovery process was not underway, so that the lawyer only had information from Jones himself.

Green independently obtained early safety standards (ASA B11.1 - 1948), and through the lawyer's office, arrangements were made for an inspection of the machine. Attending the inspection were Jones, Mr. Green, Jones' lawyer and the lawyer for Acme Products. Mr. Green made extensive measurements on the press, including dimensions of the frame, slide, clutch system, controls and their location, and details of the die set. The dies involved in the accident were no longer on the machine, but were made available for inspection by Green. Photographs of each item were taken, and Mr. Green made extensive notes regarding any apparent changes that the machine had undergone. He also had an operator run the machine, and he timed the cycling of the ram. In addition, Mr. Green also investigated the controls, particularly noting the two-hand trip method, and the fact that the two buttons were not of an anti-tie down design. He determined that either button could be held down or wedged, and the press would cycle (one stroke) when the other button was pressed. The machine bore a decal which gave its serial number, which was noted by Mr. Green.

Three weeks after the inspection, Mr. Green, called the lawyer and discussed his preliminary findings. He reported that there was clear evidence that the machine had been modified since the time of manufacture. The modification he noted was the incorporation of a pneumatic control system with a two-hand trip mechanism. In his opinion, the mechanism of actually tripping the press was not changed, and that the air system achieved exactly the same effect as the mechanical linkages which were probably used when the machine was treadle actuated. The treadle mounting bracket was still on the machine but the whole treadle mechanism was gone. Mr. Green, opined that the only significant change was from foot operation to two-hand tripping.

As far as the Jones accident is concerned, Mr. Green believed that, for whatever reason, one button, most likely the left, stuck down,probably due to a small particle of dirt in the push button mechanism. In his activity of attending to the screws in the die, Mr. Jones, had inadvertantly hit the other button, and the press cycled on

him. No doubt the particle of dirt became dislodged as people pressed the two buttons in the subsequent accident investigation, no evidence of "tie down" was ever observed.

Mr. Green explained to the lawyer that anti-tie down buttons were typically designed so that both had to be pressed simultaneously or at least within a few seconds of each other, and furthermore, both had to be released after each stroke in order to initiate a subsequent stroke. Green felt such a design in this case would have prevented Mr. Jones' accident.

With respect to the contribution to the accident by Acme Press Company, the manufacturer, Mr. Green felt that the changes made here were foreseeable to the manufacturer, that he knew or should have known that two-hand tripping would be needed or could be used on this press, and that the manufacturer therefore should have warned that two-hand tripping without additional safeguards and/or anti-tie down mechanisms was dangerous.

On this basis, Mr. Green concluded that the press was unreasonably dangerous when it left the control of the manufacturer. Furthermore, he felt that the lack of warning contributed to the accident to Mr. Jones.

With respect to the machine rebuilding company who modified the machine, Mr. Green felt that they had produced an unreasonably dangerous product because of their failure to incorporate anti-tie down buttons in the equipment.

When asked by his client if the press met the safety codes, he noted that not knowing the exact date of manufacture (or rebuild) mean that he could not yet pin point which revision of the code applies. He felt that the press probably did meet the codes, however. Nevertheless, the ANSI codes are voluntary codes for the manufacturer (and the rebuilder), so that compliance or otherwise does not necessarily define a safe or unsafe product, in his opinion.

VIEW FROM RIGHT HAND SIDE

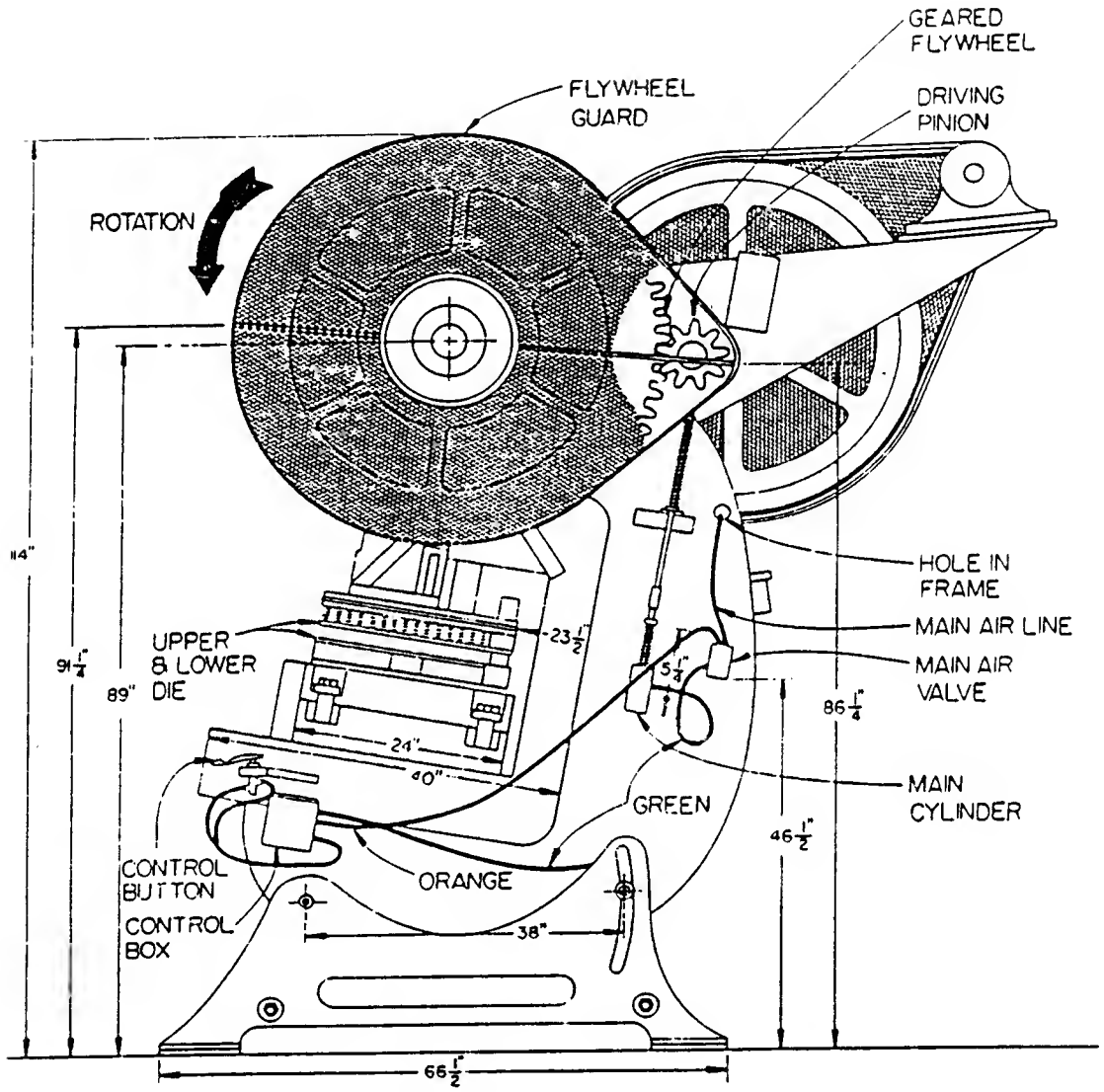


Exhibit 12. Subject Press - as Modified

FRONT VIEW OF PRESS

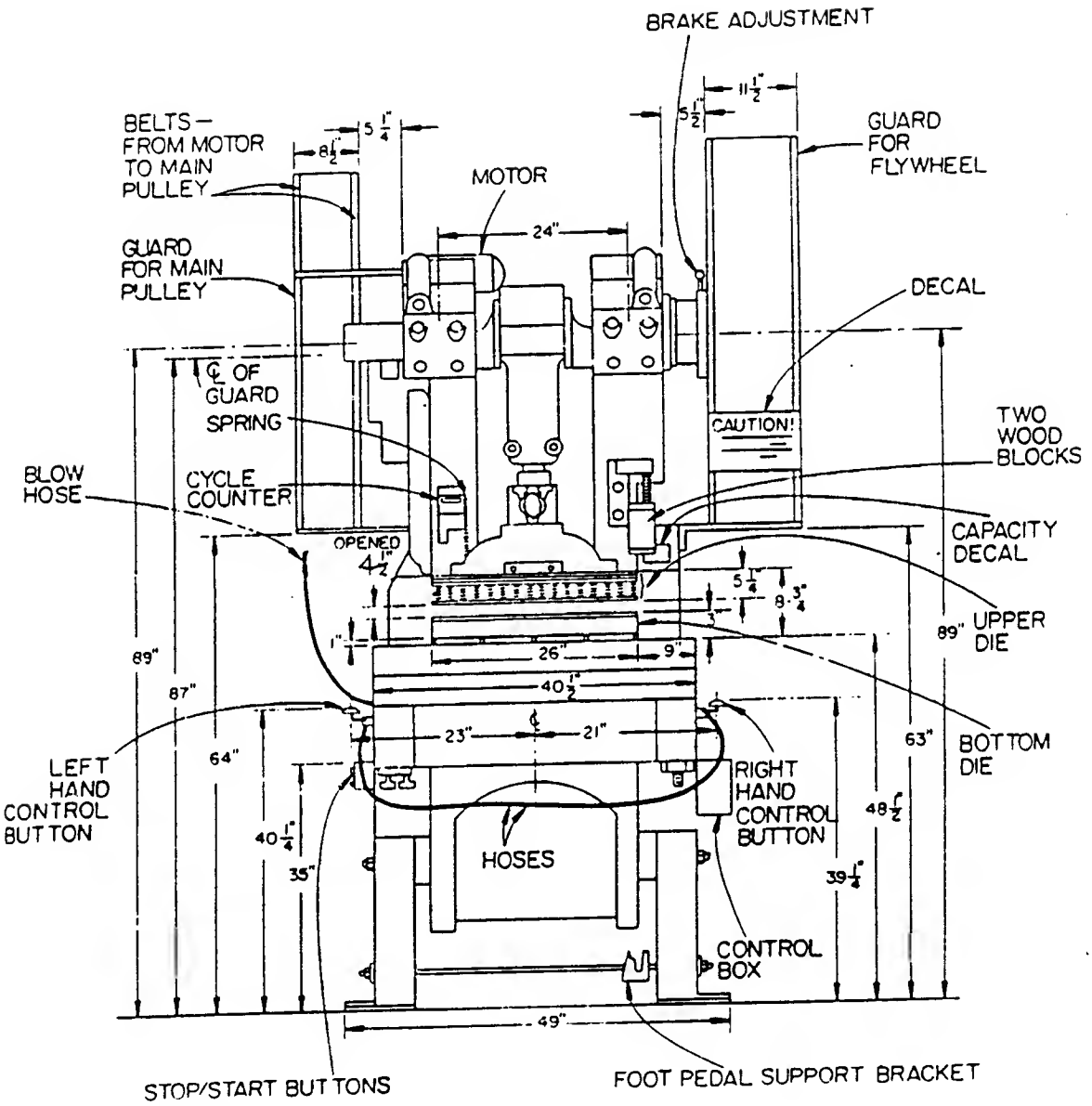


Exhibit 13. Subject Press - as Modified

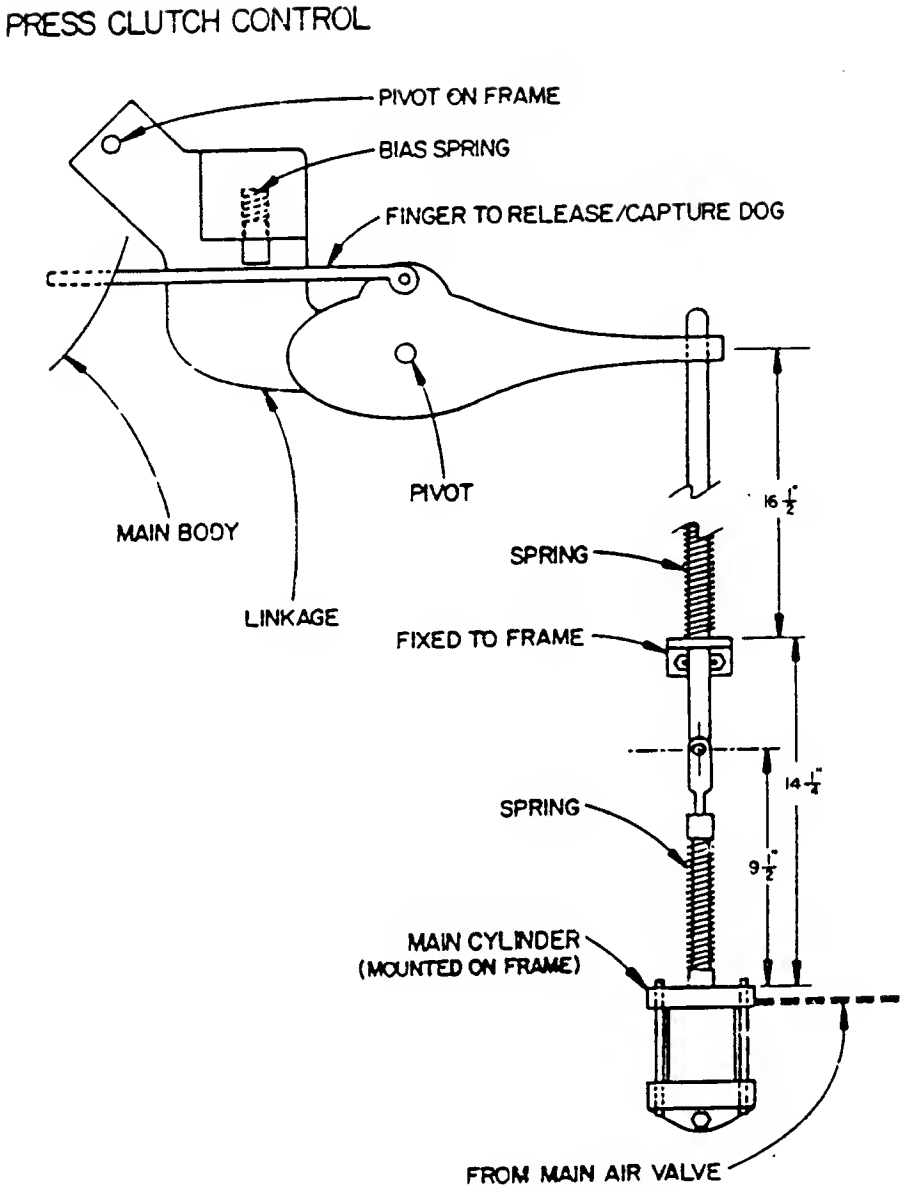


Exhibit 14. Modified Control Linkage